MacroFuels Project

FACTSHEET

Towards Sustainable, Industrial scale Cultivation of Seaweeds in Europe

Key findings from the MacroFuels Horizon 2020 research and innovation project

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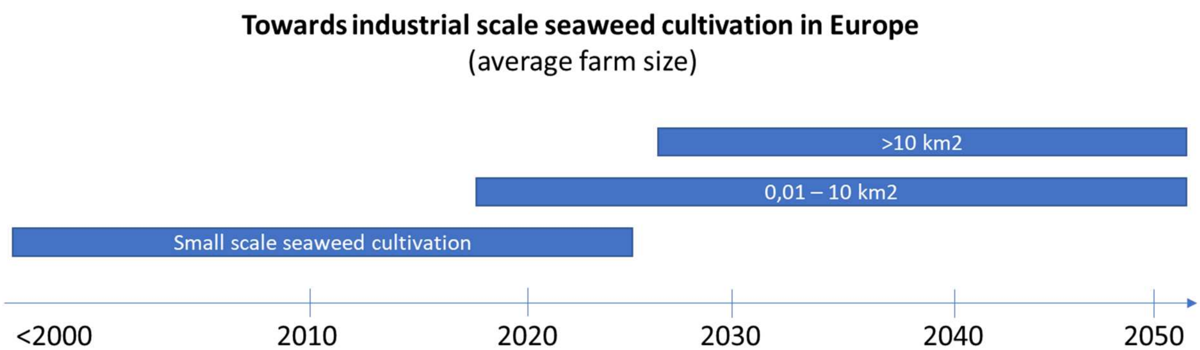
Why large-scale seaweed cultivation in Europe?

Until today the majority of seaweeds in Europe are being wildly harvested. Wild seaweed harvesting has been known for decades in countries like Norway, France, Ireland and Iceland, mainly for the production of thickening agents such as alginates (*e.g. Laminaria hyperborea*), or agar agar (*e.g. Gelidium*). Such thickening agents are typically used as food additives, for example in dairy products such as chocolate milk and ice creams. Due to the strongly increasing global demand for seaweeds (>10+% per year), the availability of some species in the wild is under pressure (*e.g.* dulse, *Gelidium*, *etc*.). At the same time the techniques applied for wild harvesting of seaweeds (*i.e*. use of drag, rotating disc and other techniques) are more and more considered as non-sustainable. As such wild harvest of seaweeds does not have a future in Europe, especially considering that recently bans for mechanised harvesting of wild seaweed have been implemented in several European countries (*e.g.* Scotland).

Seaweed cultivation in Europe only started around 2007. Today there are a few multi hectare farms but the majority are cultivating at a much smaller scale and in an artisanal manner.

Due to the various research and development projects that have been performed over the past years the number of start-ups and SME's dealing with seaweed cultivation and further processing of the seaweeds has increased strongly. This factsheet describes the progress achieved by the MacroFuels project towards future sustainable seaweed production in Europe and the technological challenges that have to be overcome in the coming years to reach industrial scale cultivation.



Manual wild seaweed harvest in Iceland

Mechanized wild seaweed harvest using dredge

Technological challenges

In order to reach industrial scale seaweed cultivation (>10 ha per individual farm) in Europe (see figure above), a number of technological challenges have to be overcome in the coming years:

- **Mechanization of all cultivation activities at sea**: Up to 1 ha scale one can perform all cultivation activities (seeding and harvesting) by hand. Operating at scales larger than 1 ha requires machines to perform these activities. Future seaweed cultivation systems will look to exploit the benefits of cultivating on 2D and 3D substrates, which requires dedicated machinery to seed and harvest the seaweed cultivation substrates.
- **Wider range of seaweed species available**: Today the number of cultivated seaweed species in Europe is limited (mostly *Saccharina latissima*, commonly known as sugar kelp, and *Alaria esculenta*, commonly known as winged kelp). There is a strong need for a wider range of cultivated species such as *Palmaria palmata* (dulse), *Porphyra/Pyropia*, and Wakame as these species have much higher commercial values compared to sugar kelp due to their chemical compositions and taste which makes them ideal species for food applications. As Wakame is an invasive species, permissions for cultivation are under debate. At the same time it will be important to further develop summer crops that can be cultivated with satisfactory yields in European waters from April-September so that seaweed cultivation becomes a year-round activity, which will be crucial for making seaweed production economically viable.
- Availability of **more sustainable seaweed cultivation substrates:** In recent years society has become aware of the enormous amounts of micro and macroplastics in the sea. As such there is a strong need for more sustainable seaweed cultivation substrates. The latter implies the development of substrates that are biobased, biodegradable and/or recyclable in time and show overall positive Life Cycle Assessment results.
- **Cultivation in offshore wind parks**: Due to various reasons *(e.g*. availability of nearshore space, visual pollution, not in my back yard (NIMBY), *etc*.) the future of large scale seaweed cultivation is expected to be in offshore areas (> 5 km from the shore). To avoid competition over the ocean space with other users, for example fisheries or offshore energy infrastructures, *co-use* or *multi-use* scenarios of the ocean space will become important in the coming years. In pilot activities the combination of seaweed cultivation and offshore wind parks (possibly in combination with other forms of aquaculture) has shown good potential. In 2020 the Belgian-Dutch project Wier & Wind will target the technological feasibility of this activity in the North Sea.
- **Integrated Multi-Trophic Aquaculture (IMTA)**: The combination of seaweed cultivation, being an extractive/bioremediating form of aquaculture, with other form(s) of aquaculture (*e.g.* salmon, bivalves (*e.g.* mussels, oysters, scallops)) or static fisheries (*e.g.* prawn, crab and lobsters), needs to be further developed. Large scale demonstration and quantification of this bioremediation effect (*i.e.* uptake of Nitrogen and Phosphorus) is a must.
- **Reduction of cultivation costs**: Today the CAPEX of an offshore 1 ha seaweed farm is appr. 300 kEUR. This cost has to be reduced 5-10-fold in order to open new applications such as biobased materials and bioenergy. A part of this reduction comes from upscaling; another part has to come from technological developments. At the same time OPEX has to be reduced. This will have to be

induced by mechanizing most of the activities in and around the seaweed farm (*e.g.* seeding and harvesting).

- **Product development**: Today the main applications for seaweeds in Europe are food, food additives and cosmetics. However, these applications currently represent niche markets. It is expected that in the next 3-5 years new, larger scale applications such as feed (additives), bioactives, biomaterials and biobased plastics will appear. Based on MacroFuels success in producing advanced fuels from seaweed, in the long run (> 5 years from now) biofuels based on seaweeds can be expected to reach technological and market maturity. The development of specific products for these markets will be of utmost importance in the coming years.

Apart from the above mentioned technological challenges there are also a number of non-technological challenges that have to be tackled in order to establish a florishing European seaweed industry. One of these is the **access to cultivation permits**. Recent experiences in Norway, Denmark, UK and the Netherlands have demonstrated that seaweed farms have to face lengthy procedures, administrative and regulatory hurdles and challenging environmental monitoring requirements to obtain such permits.

Large-scale seaweed cultivation will generate changes to the surrounding marine environment. Many of these changes can be considered as positive, *i.e.* uptake of CO_2 and nutrients - mitigating climate change and counteracting eutrophication. Authorities need to define acceptable thresholds for environmental change to better assess the carrying capacity of the receiving environment with respect to conservation objectives, and following agree on general guidelines for good cultivation practice, including monitoring programs, avoiding the costly collection of “data-rich, information-poor” data, while still securing documentation of positive and negative environmental impact.

Key benefits of sustainable, industrial scale seaweed cultivation are:

- ✓ 29-39 tons of CO_2 capture per hectare
- ✓ Substantial bioremediation effect (removal of excess nitrogen (*i.e.* 5-60 kg N pr. ton of seaweed dry matter) and phosphorous from the environment), especially when in close proximity of non-extractive aquaculture activities (*e.g.* salmon farms) or in other nutrient rich environments
- ✓ No need for land, fresh water or additional fertilizer
- ✓ Positive impact of biodiversity
- ✓ Novel biomass source for food, feed, biomaterials, biofuels, *etc*.

Key challenges related to sustainable, industrial scale seaweed cultivation for the near future are:

- ✓ Mechanization of all cultivation activities at sea (seeding and harvesting)
- ✓ Development of more sustainable seaweed cultivation substrates with controlled biodegradation properties
- ✓ Efficient cultivation in offshore wind parks (*i.e*. multi-use of space)
- ✓ Development and demonstration of integrated multi-trophic aquaculture (IMTA) farms
- ✓ Reduction of cultivation costs (*i.e.* investment (CAPEX) and operating (OPEX) costs) by a factor 5-10
- ✓ Development of new, innovative products (*i.e.* food, feed, biomaterials, biofuels, *etc*.) based on seaweeds

MacroFuels steps towards large-scale seaweed cultivation

MacroFuels strongly contributed to the development of industrial scale seaweed cultivation by:

- ✓ Developing novel 2D cultivation substrates (*i.e.* horizontal and vertical net structures)
- ✓ Reaching cultivation yields of 9 kg of seaweeds (wet weight) per linear meter
- ✓ Improving the cost-efficient, direct seeding procedure
- ✓ Developing a conceptual design for a mechanical harvester for 2D cultivation substrates that can operate at 1000 m^2 per hour
- ✓ Developing novel storage solutions for harvested seaweeds

Project Identity

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